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ONTARIO WATER RESOURCES

COMMISSION

BIOLOGICAL SURVEY

of the

WELLAND RIVER

1964

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ONTARIO WATER RESOURCES COMMISSION

REPORT

On The

BIOLOGICAL SURVEY OF THE WELLAND RIVER - 1964

By

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Biology Branch

November, 1964.

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SUMMARY

A biological survey of the Welland River was made by the Commission in June and July, 1964 in co-operation with the Conservation Authorities Branch, Department of Energy and Resources Management. Fish, bottom fauna, zooplankton and algae populations were examined at several stations between Port Davidson and Chippawa.

Twelve species of fish and 19 genera of bottom organisms, including pollution-intolerant mayflies of two genera, were found at three stations upstream from the City of Welland. Slight changes in the fish population and a reduction in the number of genera of bottom organisms indicated mild pollution in the river just above Welland, presumably as a result of upstream circulation of wastes from Welland.

A reduction in the number of species of fish to five and genera of bottom organisms to six indicated heavy pollution below Welland. The presence of a fish population below Welland demonstrated the importance of the addition of dilution water from the Welland Canal to the river. Partial recovery was indicated at Port Robinson.

The toxic nature of high-ammonia waste from Cyanamid of Canada Limited (Welland Works) was indicated by the presence of only one fish species and two genera of bottom organisms, all with low populations. The effects of this toxic discharge were evident at Chippawa at the mouth of the Welland River.

Lyons Creek above the confluence with the Welland River was moderately polluted. Eleven species of fish and nine genera of bottom organisms were found. Relatively large standing crops of both groups indicated considerable enrichment.

Zooplankton populations were relatively great above Welland and considerably reduced at all stations below the City. Algae populations were uniformly low at all stations except downstream from Cyanamid where a varied and abundant population flourished presumably promoted by high concentrations of nitrogen and phosphorus from municipal and industrial wastes.

The Welland River above Welland is characterized by low flows, turbid conditions and waters relatively rich in nutrients. To prevent winterkills of fish and fish-food organisms no significant use should be made of the upper Welland for waste disposal.

Welland's plans to provide primary and eventually secondary treatment to its wastes will improve the biological populations and aesthetic qualities of the lower river. However, the release of dilution water from the Welland Canal should be continued.

The ammonia levels of wastes from the plant of Cyanamid of Canada Limited should be reduced considerably to prevent the continuation of toxic conditions downstream and avoid unnecessary enrichment of receiving waters in the Niagara River and Lake Ontario.

The upper Welland is used for a variety of recreational activities, while multiple use of the river below Welland is curtailed because of municipal and industrial pollution. Most riparian land is zoned as greenbelt by the municipalities of Niagara Falls, Thorold Township and Willoughby Township. Therefore, multiple use of the lower Welland valley is potentially possible. Implementation of proposals for waste disposal in the City of Welland including the diversion of water from the Ship Canal and improvements in waste treatment by Cyanamid of Canada Limited would make multiple use of the valley practical.

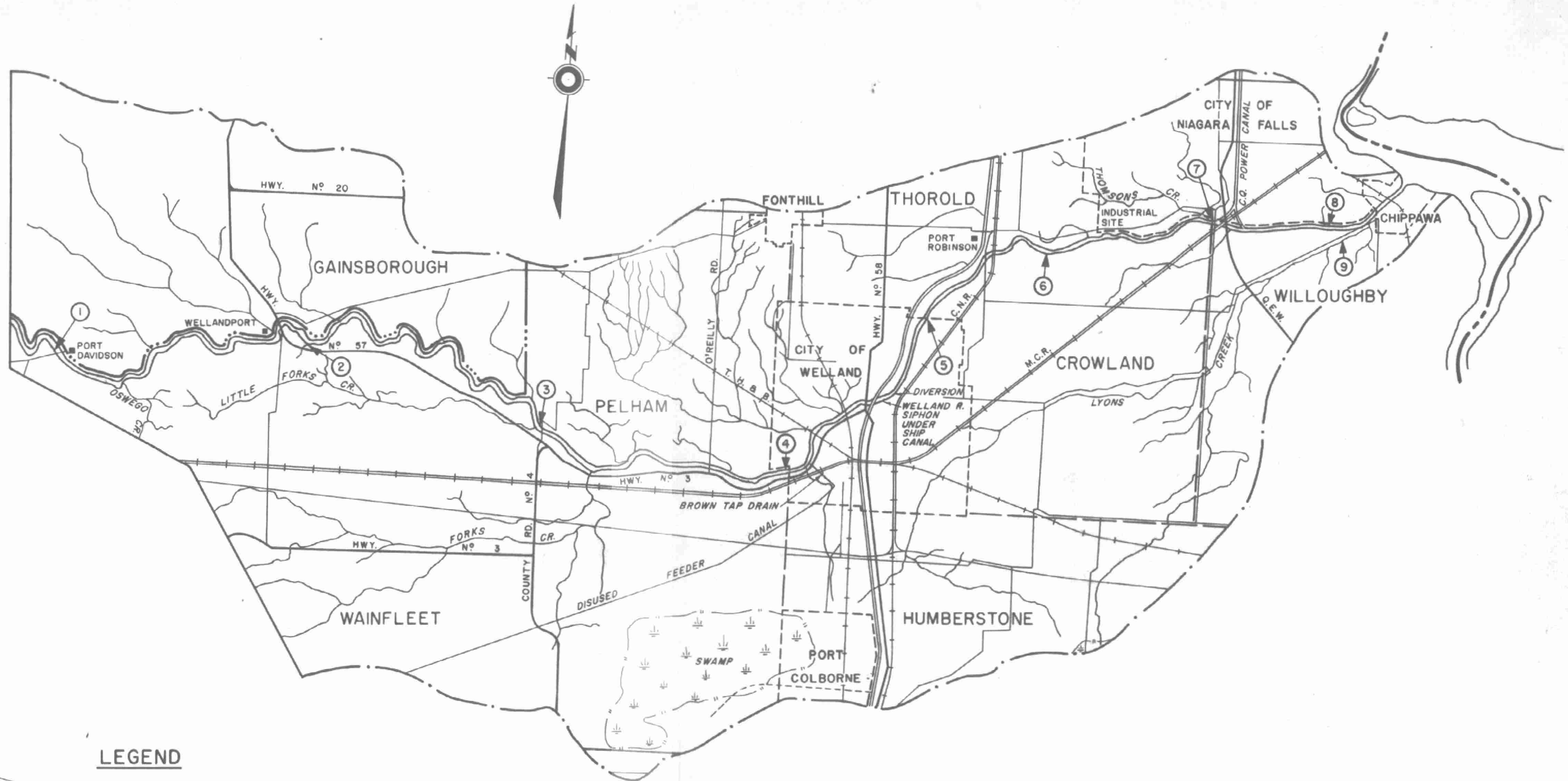
BIOLOGICAL SURVEY OF THE WELLAND RIVER - 1964

INTRODUCTION

Examination of the plant and animal communities of a watercourse provides information of practical value in the interpretation of water quality. Most of the changes in characteristics of the water which adversely affect the amenities of the watercourse are associated with evident alterations to these communities. The extent of biological imbalance indicates the degree to which water quality has been changed. Plant and animal communities not only reflect water quality over a considerable period of time prior to examination, but they also place the interpretation of water quality on meaningful terms. The data provide a useful basis for the comparison of future changes in water. For these reasons the populations of fish, bottom fauna, zooplankton and plants were examined at several points on the Welland River in the summer of 1964.

SURVEY METHODS

Most of the field work was completed during the period June 22 to 26. Field parties of the Biology Branch of the Commission and of the Conservation Authorities Branch, Department of Energy and Resources Management, operated jointly to sample fish and bottom fauna populations at nine stations between Port Davidson and Chippawa (Fig. 1). On July 22, the Biology Branch made zooplankton collections at these stations. Water samples for algae examination were taken by the Stream Sanitation Branch on July 7 and 8 in the course of that Branch's studies of the Welland River.



LEGEND

7	BIOLOGICAL SURVEY STATIONS
	WATERSHED BOUNDARY
	TOWNSHIP BOUNDARY
	CITY, TOWN & VILLAGE BOUNDARIES
	COUNTY BOUNDARY
	INTERNATIONAL BOUNDARY

ONTARIO WATER RESOURCES COMMISSION

FIGURE I

LOWER WELLAND RIVER

LOCATION OF BIOLOGICAL SURVEY STATIONS

SCALE: 1" = 2 MILES	
DRAWN BY: A.R.S.	DATE: OCT., 1964
CHECKED BY:	DRAWING Nº: 64-76

Fish

A 100 x 10-foot bag seine of ¼-inch mesh was employed in collecting fish. Four or five hauls were made at each station except at Station 5 where adverse conditions limited the effort to one haul. The net was placed and hauled by boat to sample an area of approximately 2000 to 3000 square feet with each unit of effort. With this method each fish population may be described qualitatively. Standing crops at the nine stations may be compared only on a relative basis. The fish were counted and weighed at the laboratory.

Bottom Fauna

Bottom sediments were collected using an Ekman dredge, which removes a section measuring 9 x 9 inches to a maximum depth of about 3 inches. Sediments were washed through 30 mesh-per-inch screen. Macroscopic animals were collected from the detritus which remained. Usually six dredgings were made at each station. Organisms were sorted, identified to genus, counted and weighed (wet weight) at the laboratory.

Zooplankton

A plankton tow-net of 140 mesh silk (#20) and 18 inches in diameter was hauled for 3 minutes at minimum motor power at each station. The displacement volume of each collection was measured and the organisms identified to genus.

Plants

Populations of rooted plants and filamentous algae were described in general terms as the survey was carried out. The microscopic algae were identified to genus and notes made on the general abundance of algae among stations.

DESCRIPTION OF THE WELLAND RIVER

The Welland River drains an area of 350 square miles of the Haldimand Clay Plain, an area of little relief sloping gently from west to east. The river originates on the eastern edge of Ancaster Township and flows 80 miles with an average gradient of only three feet per mile to the Niagara River. Steeper gradients in the headwaters contribute to erosion there and turbidity downstream, where the gradient in the final wide and sluggish 50 miles is less than 1 foot per mile.

Low dry-weather flows and on occasion no flow at all are characteristic of the river above Welland. The flow at Welland is augmented by the diversion of about 250 cfs from the Ship Canal. Apparently the flow of diversion water had been reduced prior to this survey to approximately 145 cfs.

The flow in the last four miles of the Welland River is reversed normally to supply water from the Niagara River to the intake of the Chippawa-Queenston Power Canal. However, at the time of the survey the canal was inoperative as repairs were being made throughout the spring and summer months.

The river is slightly under 100 feet in width and about 5 feet deep at Station 1. The river widens and deepens above Station 2. At most stations maximum depths of between 12 and 18 feet were observed. At Station 8 the river is approximately 300 feet wide and 25 feet deep.

Sanitary surveys made by the Commission in the past several years have indicated that the Welland River was of fair quality above Welland but water quality deteriorated as the river proceeded through that city. Considerable domestic and industrial pollution from Welland, which has no waste treatment facilities to date, has been evident in high BOD concentrations and coliform counts and excessive iron and phenol concentrations in downstream waters. Cyanamid of Canada Limited (Welland Works) disposes of wastes to Thompson's Creek and to the lower Welland River. Some domestic wastes are discharged to the lower Welland by the City of Niagara Falls from its Stanley Road settling tank. Lyons Creek has been reported as grossly polluted in and below Welland. Forks Creek and Little Forks Creek have at times shown impairment due to minor sources of pollution.

The Stream Sanitation Branch monitored water quality on the Welland River during the spring and summer of 1964. Data from the June survey is most pertinent to the biological survey which was carried out shortly after physical-chemical sampling. Information on BOD, solids, colour, turbidity, phenol, iron, nitrogen, phosphorus and detergent concentrations was collected. Coliform levels also were determined (Table 1). Such data are of use in postulating the causes of disturbances to biological populations.

FISH POPULATIONS

Species Present

Eighteen species of fish were taken by seine net from the Welland River, not a large number of species for a Southern Ontario stream, but probably representative of heavily silted, slow-moving waters. The following species were taken: white sucker, Catostomus commersonnii; carp, Cyprinus carpio; golden shiner, Notemigonus crysoleucas; creek chub, Semotilus atromaculatus; emerald shiner, Notropis atherinoides; spottail shiner, Notropis hudsonius; bluntnose minnow, Pimephales notatus; brown bullhead, Ictalurus nebulosus; tadpole madtom, Schilbeodes gyrinus; mudminnow, Umbra limi; northern pike, Esox lucius; killifish, Fundulus diaphanus; rock bass, Ambloplites rupestris; pumpkinseed sunfish, Lepomis gibbosus; white crappie, Pomoxis annularis; black crappie, Pomoxis nigromaculatus; yellow perch, Perca flavescens and johnny darter, Etheostoma nigrum.

The rock bass and creek chub were found in the lower portion of Lyons Creek but not in the Welland River. The golden shiner, crappies,

Table 1. Physical-chemical characteristics and coliform numbers on June 10-11, 1964 at the seven stations on the Welland River monitored by the Stream Sanitation Branch.

Station	D.O* (ppm)	B.O.D. (ppm)	Solids (ppm)			Colour (units)	Turb. (units)	Phenol (ppb)	Iron (ppm)	Nitrogen (ppm as N)				Phosphorus (ppm as PO_4)		Detergent (ppm as A.B.S)	Coliforms (M.P.N.)
			Total	Susp.	Diss.					NH_3	Org.N	NO_2	NO_3	Tot.	Sol.		
County Rd.#4 (PW-27.0)	5.8	1.6	376	---	---	235	79	11	3.06	.30	1.5	.01	---	1.0	0.20	0.0	978
O'Reilly Rd. (PW-21.2)	5.2	1.7	494	142	352	405	180	8	6.16	.70	2.0	.02	0.4	2.3	0.40	0.0	8,400
Highway #58 (PW-18.6)	6.1	2.3	261	21	243	17	15	8	1.10	.37	1.5	.01	0.3	0.7	0.28	0.1	40,400
300' below Waterworks (PW-18.2)	5.9	1.9	287	19	268	21	23	8	1.66	.76	1.5	.01	0.3	1.0	0.47	0.3	43,100
500' below 96 inch sewer (PW-17.4)	6.0	1.7	285	28	269	40	27	10	3.05	.78	1.7	.03	1.0	1.0	0.08	0.3	59,200
Port Robinson (PW-14.6)	7.0	1.5	266	17	250	13	13	9	1.01	.36	1.5	.02	0.3	3.8	0.25	---	3,700
Montrose (PW-9.3)	11.4	3.5	302	13	288	20	10	6	0.62	17.00	24.0	.03	0.3	1.5	1.50	0.2	49

* at water temperatures of 72 to 81 °F.

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* at water temperatures of 72 to 81 °F.

pike, mudminnow and Johnny darter were not taken from Lyons Creek but the latter two species rarely were taken in the Welland River.

Composition of Fish Populations

The numbers of fish of each species caught at the nine stations are provided in the Appendix. Because the number of hauls made with the seine net varied among stations, data are of most interpretative value when converted to catches per unit of effort (Table 2).

Fish populations at Stations 1, 2 and 3 were similar in most respects. Sunfish (including crappies) and catfish made up the bulk of the catch by number with the former predominant and both groups more numerous than minnows. However at Station 4 the order of abundance was reversed to minnows - catfish - sunfish. This was not the result of a decline in the sunfish population, but, rather, an increase in the populations of each of the four species of minnows encountered upstream and the addition of the spottail shiner.

Station 5 had a very different fish population from those observed above Welland. The carp predominant, while sunfish and all minnows but the bluntnose minnow were absent. The perch, golden shiner and spottail shiner returned at Station 6. Carp and bullheads were common, but no sunfish were taken.

At Station 7, a single bullhead was taken in four seine hauls. Only 5 fish were taken at Station 8, the lowermost station on the Welland River. However, at Station 9 on Lyons Creek the fish population was varied and abundant. With carp, bullheads and several of the minnows previously encountered comprising the population, a resemblance to Station 6 was evident. The rock bass and pumpkinseed sunfish were present but not abundant.

Table 2. Catches of fish per unit of effort from stations on the Welland River, 1964.

Species	Stations 1	2	3	4	5	6	7	8	9
White sucker								0.5	0.3
Carp		0.4		1.3	6.0	1.3			0.5
Golden shiner	1.0	1.0	0.3	0.8		10.7			
Creek chub									0.3
Emerald shiner		0.2	0.3	0.8					7.6
Spottail shiner				4.0		0.3		0.5	49.3
Bluntnose minnow		1.4	1.3	14.3	1.0	0.7			0.3
Brown bullhead	3.6	3.2	1.8	8.3	1.0	3.7	0.2		15.0
Tadpole madtom	0.6	0.4	0.5						0.3
Mudminnow			0.3						
Northern pike	0.6	0.6			1.0				
Killifish					1.0				
Rock bass									0.5
Pumpkinseed	0.6	4.6	3.0	2.5					0.8
White crappie	2.2	0.4	0.5	1.5					
Black crappie	2.0	2.2	1.0	1.8					
Yellow perch	0.2	1.4	0.5	2.8		1.0		0.3	0.5
Johnny darter				0.3					
Total fish	10.8	15.8	9.5	38.4	10.0	17.7	0.2	1.3	75.4
Total Weight (lbs.)	.60	.46	.21	4.43	5.19	1.16	.05	.06	29.83

Magnitude of Fish Populations

The populations, expressed on the basis of weight of fish taken per unit effort, indicate production in general terms (Table 2). The river at the upstream Stations 1, 2 and 3 appeared to be much less productive (.60, .46 and .21 pounds of fish per unit effort) than Stations 4 and 5 in Welland (4.43 and 5.19 pounds). The catch at Station 6 was intermediate (1.16 pounds). At Stations 7 and 8 the smallest catches were taken (.05 and .06 pounds), while Station 9 gave the greatest harvest (7.46 pounds per unit effort). The numbers of fish caught with each unit of effort varied similarly among the nine stations. Station 8 provided the least. Catches at the upper six stations were similar with the exception of Station 4 where greater numbers of fish were taken.

Effects of Pollution on Fish

It is evident that both the magnitude and composition of fish populations varied among the stations (Fig. 2). Populations at the upper three stations were composed of a dozen species, each with relatively low standing crops. Production is naturally reduced by very turbid waters, but these fish populations were in the process of recovering from a reported winter-kill which occurred two years earlier. Almost every fish captured was 1 or 2 years of age, and the standing crops of these populations probably had not attained former levels. However, in most respects, the populations at Stations 1, 2 and 3, which are above major sources of pollution, provide an excellent basis for comparison with fish populations in waters downstream.

The population at Station 4 was decidedly different from upstream populations. The relative abundance of the species was altered with minnows and bullheads occurring in greater numbers. However, sunfish

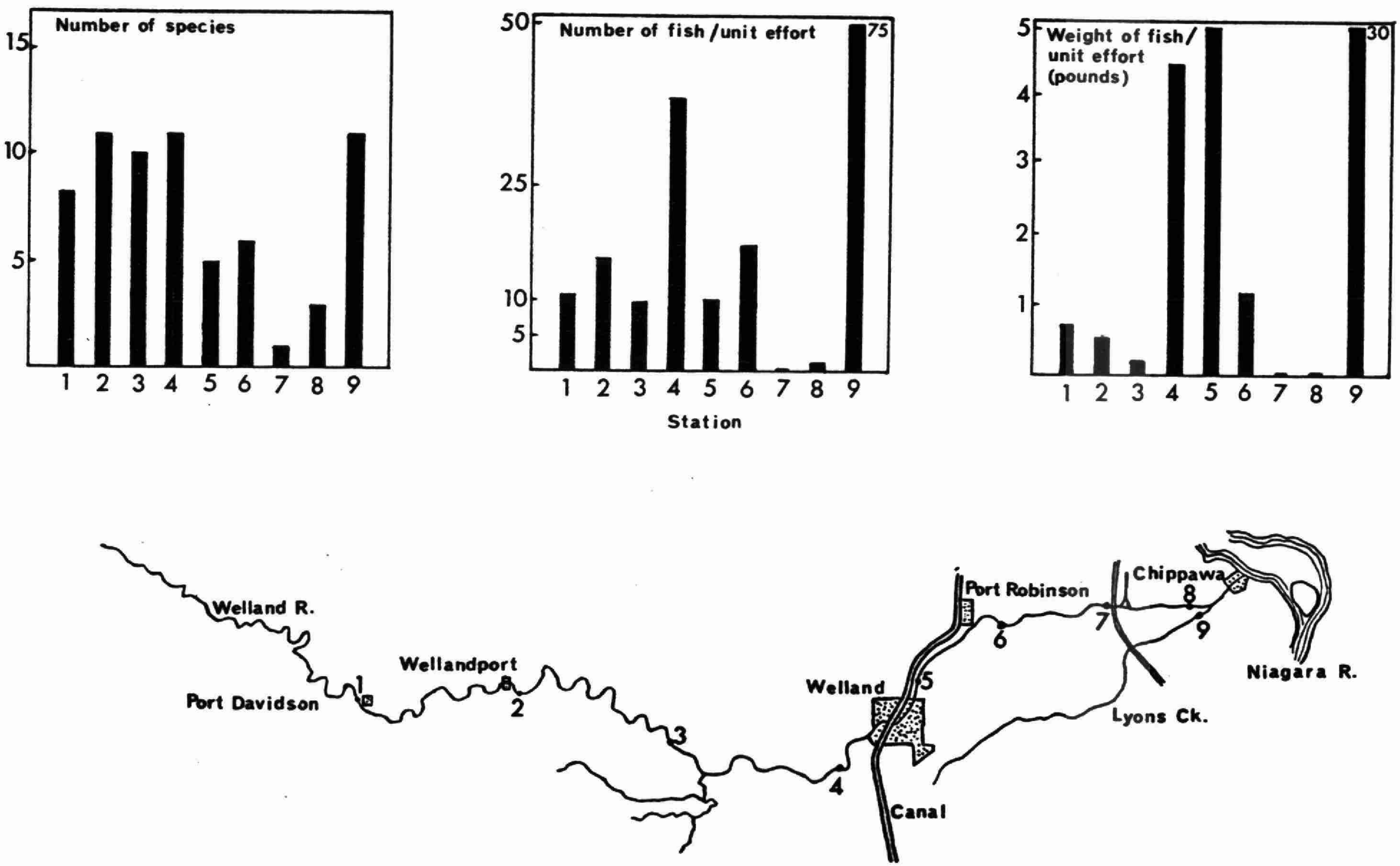

Fig. 2. Number of species and number and weight of fish taken per unit of effort at nine stations on the Welland River in June, 1964.

were as abundant as upstream. A much greater standing crop of fish was indicated, although this population lacked older fish. These changes in the fish population indicate mild pollution, probably derived from back-circulation from open drains and sewers located a short distance downstream.

Only five species were taken at Station 5. Crappies, pumpkinseed sunfish, perch and the three shiners were absent. The standing crop of pollution-tolerant carp was at a high level, indicating considerable enrichment of these waters and sediments. The seven species which failed to inhabit this zone were excluded because of periodic reductions in dissolved-oxygen concentrations, toxic components of industrial wastes, alterations to invertebrate populations upon which they feed or combinations of these factors.

Dissolved oxygen concentrations were surprisingly high below Welland. No values below 50% saturation were recorded on June 10 and 11 (Table 1). Diurnal fluctuations were not widespread as determined on July 7 by the Stream Sanitation Branch of the Commission. Above Welland (Station 3) high and low values of 6.3 and 4.1 ppm were recorded, while below the city (at a point not far below Station 5) high and low concentrations of 5.5 and 3.7 ppm were measured. The addition of water from the Welland Ship Canal must certainly account for this preservation of relatively well aerated waters below Welland. Conceivably, conditions above Welland would be much more severe during the period of ice cover, as evidenced by occasional winter-kills of fish in the past, while water quality below Welland probably would be most degraded during very hot weather. Therefore, the concentrations of dissolved oxygen observed below Welland may be typical of the most severe depletion which occurs at that point. Such is not true of the levels of oxygen observed above Welland - winter concentrations probably are much less.

The concentrations of phenols, iron and detergent detected in the June 10-11 survey would not damage fish directly. Suspended solids were moderately high below Welland, 20 to 30 ppm, but less by far than above Welland due to the addition of less turbid dilution water from the canal. Certainly large amounts of solids, derived from above as well as from the city, are deposited. The continuous deposition of solids and the formation of a substrate suitable for little life other than annelids probably is a major factor controlling the distribution of fish. The common fish at Station 5, the carp and bullhead, are able to utilize such a bottom fauna.

More fish of a greater number of species were captured at Station 6, which indicates partial recovery from the heavy waste load received at Welland. The recovery process continues downstream until effluents from the Cyanamid plant produce their very devastating effects, which were noted at Stations 7 and 8 in insignificant catches of fish. Station 9, with its varied and abundant fish population, is not seriously affected if at all by the Cyanamid wastes and serves well for comparison purposes. In fact the large population in Lyons Creek may have been augmented by fish escaping from the lower Welland when the flow of Niagara River water to feed the power canal was halted in the spring. The effects if any, of domestic wastes from Niagara Falls are overshadowed by the passage of wastes from Cyanamid of Canada Limited through the lower Welland River.

At Station 7 the concentration of ammonia was high, 15 to 20 ppm on June 1. Station 8 also was affected by high ammonia concentrations, as demonstrated in September, 1964, with 7 ppm when water at Station 7 contained 16 ppm of ammonia. Ellis estimated the lethal limit for ammonia to be about 2.5 ppm at pH values between 7.4 and 8.5. At Stations 7 and 8 pH values were 8.4 and 7.8 respectively. Oxygen concentrations were found to be

very high because of the large populations of algae. Oxygen levels at night undoubtedly were much lower but were not measured. The downstream succession in concentrations of oxygen and ammonia is shown in Fig. 3 .

A Comparison of Fish Populations

The degree to which the species composition of fish populations may be similar among the nine stations is determined using the coefficient of similarity (Burlington, 1962) which is explained in Table 3. Stations 1, 2 and 3, as expected, are quite similar (Table 3). The population at Station 6, where some recovery has taken place, is similar to that at Station 4 where mild pollution was indicated. Apparently a fair degree of recovery has been achieved below Port Robinson, although considerable enrichment persists. Station 9 had a population similar to those at Stations 2 and 4, which would indicate little if any damage to the fish population in the lower portion of Lyons Creek. Stations 7 and 8 are set off as markedly different from any others on the Welland River and indicate severe damage to the fish populations at those points. As well, the fish population of Station 5 is quite different from that at any other station.

BOTTOM FAUNA

Genera Present

The Welland River showed little variety in benthic organisms -- only 28 genera were encountered in the 1964 survey. One-half of these were annelids and midge larvae (Table 3). Certainly a greater variety could have been observed if the shoreline fauna had been investigated. However, for the purpose of this survey, only benthic forms were sampled.

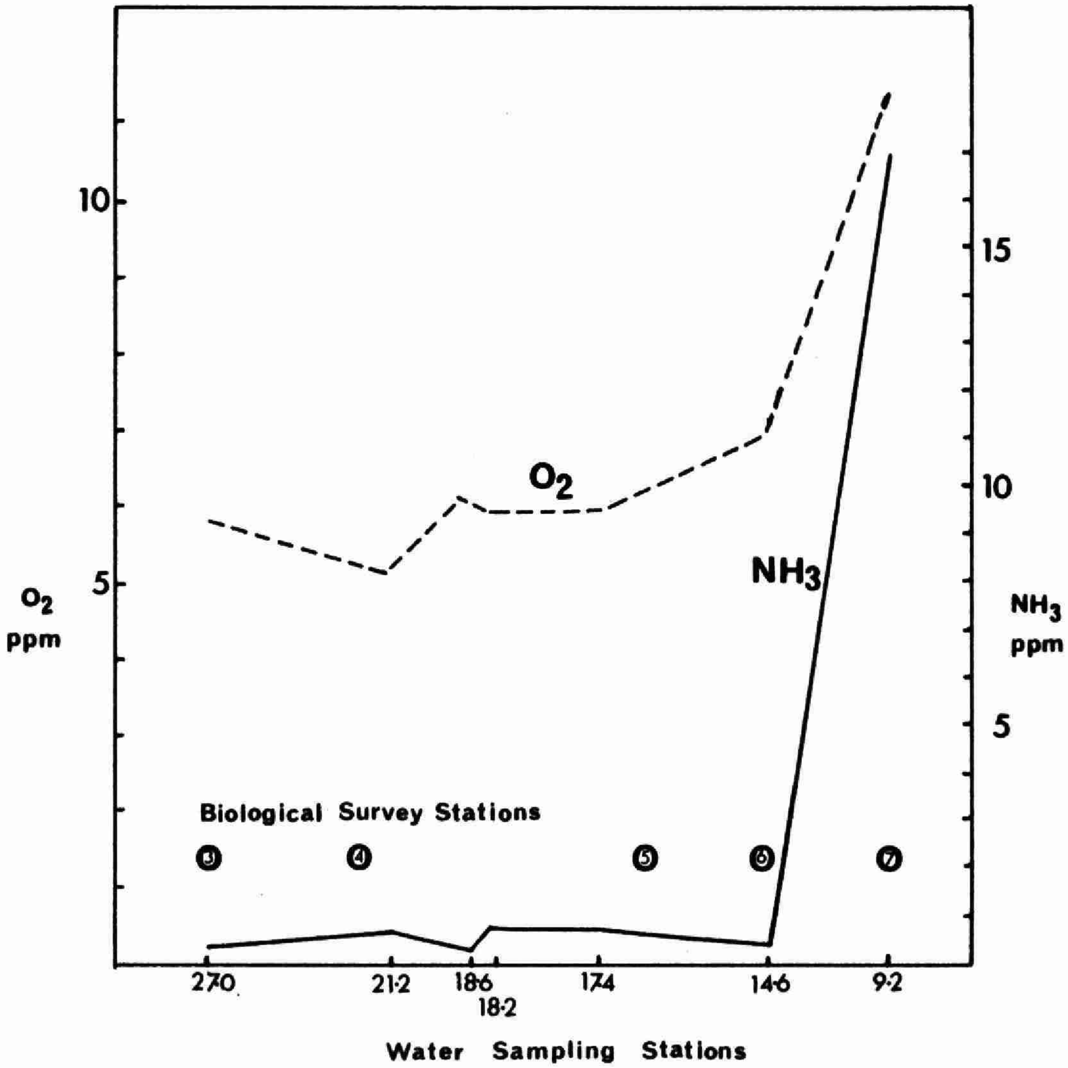

Fig. 3. Concentrations of dissolved oxygen and free ammonia at seven stations on the Welland River on June 10-11, 1964.

Table 3. Degree of similarity in composition of fish populations among nine stations on the Welland River as expressed using the coefficient of similarity (explained by example below).

	STATION 1	2	3	4	5	6	7	8	9
1									
2	.84								
3	.78	.86							
4	.63	.82	.76						
5	.31	.50	.27	.38					
6	.43	.59	.50	.71	.55				
7	.22	.17	.18	.17	.33	.29			
8	.18	.14	.16	.29	.00	.44	.00		
9	.42	.64	.57	.64	.38	.59	.17	.43	

$$\text{Coefficient of similarity (Stations 1 and 2)} = \frac{2 \times \text{number forms common to both stations}}{\text{number forms at 1} + \text{number forms at 2}}$$

Composition of Bottom Fauna

The numbers of individuals of each genera taken in each dredge collection at the nine stations are appended. Average catches per square foot of bottom are of greater significance and are provided in Table 4. Bottom fauna populations at Station 1, 2 and 3 were similar and exhibited a variety of forms including two mayfly species, Hexagenia limbata and Caenis Sp., Gammarus, Asellus and a variety of midge larvae. No mayflies, fewer midges and more annelids were collected at Station 4. At Station 5 the annelids, Limnodrilus and Tubifex were abundant, their only associates being the carnivorous midge Procladius and three species of molluscs. The bottom fauna at Station 6 was similar although no Tubifex was found in the worms collected and Sphaerium replaced Pisidium of Station 5. Only Limnodrilus and its predator Procladius were collected at Station 7. Annelids, clams and a greater variety of midges were taken at Station 8 and 9. No mayflies, amphipods or isopods were found in the lower Welland River.

Data on the weight of macroinvertebrates collected indicate relative production, which would appear to be relatively low in the upper Welland (.05-.16 gram/sq.ft.) and high below (.34-2.75 gms./sq.ft.) except at Station 7 (.11 gm./sq.ft.)

Effects of Pollution on Bottom Fauna

The bottom fauna, because of its varied, sensitive and fixed nature, represents one of the most useful groups in assessment of water quality. The groups of most importance of those collected from the Welland River are the pollution-tolerant annelids, the tolerant to semi-tolerant midges, the semi-tolerant Gammarus and Asellus and the intolerant mayflies.

The bottom fauna found at Station 1, 2 and 3 may be considered typical of unpolluted waters of the Welland River, and may be compared with the lower stations. Small differences among stations must be considered

Table 4. Average numbers of individuals per square foot of the 28 genera comprising the bottom fauna of the Welland River, June, 1964.

Genus	Stations 1	2	3	4	5	6	7	8	9
Oligochaets									
<u>Limnodrilus</u>	2.3	2.3	.5	22.0	308.0	293.6	9.5	21.6	11.3
<u>Tubifex</u>					18.0			6.7	2.3
<u>Lumbriculus</u>								1.4	
Leeches									
<u>Erpobdella</u>								.5	
Amphipods									
<u>Gammarus</u>	4.1	2.3	1.3	.5					
Isopods									
<u>Asellus</u>	5.6	1.3	.5	.4					
Mayflies									
<u>Hexagenia</u>	1.4	1.3							
<u>Caenis</u>	.9	.4	.4						
Alderflies									
<u>Sialis</u>									.5
Beetles									
<u>Dubiraphia</u>	.9		.4						
<u>Helophorus</u>						1.8			
Flies									
<u>Chaoborus</u>	.5	.9							
<u>Palpomyia</u>		1.4	.5						1.8
<u>Procladius</u>	.5	4.1	.4	.5	1.8	1.8	20.0	11.3	.5
<u>Anatopynia</u>				.4					
<u>Chironomus</u>		2.3						1.8	
<u>Cryptochironomus</u>	1.3	.4	.5					.4	.5
<u>Glyptotendipes</u>		.4	2.2						
<u>Tanytarsus</u>	.5								
<u>Polypedilum</u>	1.8	2.7	1.8					1.3	6.5
<u>Calopsectra</u>				.4					1.1
<u>Tipula</u>		.4							
Mites									
<u>Hydrachna</u>	.4								
Molluscs									
<u>Margaritifera</u>	.4								
<u>Valvata</u>					1.8	11.0			
<u>Campelloma</u>					.5				
<u>Sphaerium</u>	2.3	1.8	.9	.9		.5		9.5	2.9
<u>Pisidium</u>					1.3			4.9	
Total Number	23	22	9	25	349	308	30	58	29
Total Weight(gms.)	.16	.09	.05	.09	2.75	1.19	.11	1.17	.34

as possibly due to sampling or naturally occurring succession. Gross differences in species-composition and standing crops are due to altered quality of waters and sediments.

The absence of mayflies, the crayfish, _Orconectes_, and certain midges and the greater numbers of annelids at Station 4 indicates mild pollution just upstream from Welland. Because an increase in standing crop was not apparent, the extent of organic enrichment must be limited.

The large increase, at least 25 times, in the standing crop of bottom fauna and reduction in the numbers of species to tolerant annelids indicates excessive organic enrichment at Station 5. The presence of the operculate snails, _Valvata_ and _Campelloma_, demonstrates that septic conditions are not attained at Station 5. Station 6 was similar to 5, but the reduced standing crop indicates less organic enrichment at that point.

The presence of only two species, _Limnodrilus_ and _Procladius_, each with very low standing crops, indicates toxic pollution at Station 7. A greater bottom fauna population would be expected there, particularly considering the effects of organic enrichment from the City of Welland. Discharges from the plant of Cyanamid of Canada Limited to the main river and Thompson's Creek are high in ammonia among other constituents. Therefore, toxic pollution below the Cyanamid plant not only adds to the pollution load but probably seriously impedes natural purification processes in the sediments through a reduction in the bottom fauna.

A moderately polluted condition is indicated in the lower portion of Lyons Creek below the Queen Elizabeth Way. Midges and annelids predominated, while mayflies, amphipods and isopods were absent.

The reduction in species from the upper to lower stations and the number and weight of bottom macroinvertebrates at the nine stations are shown in Fig. 4. The effects of slight organic enrichment were evident at Station 4, as were the effects of excessive enrichment at Stations 5 and 6. Low standing crops of a very few species indicated toxic pollution at Station 7. Water quality at Stations 8 and 9 appeared to be only fair as some organic enrichment was evident.

A Comparison of Bottom Fauna Populations

The coefficient of similarity may be used to assess likeness among stations, that is, the degree to which the species composition of the benthic population at one station was like that at another. The coefficients are provided in Table 5 in which six values exceeding .60 are designated. The bottom fauna at Stations 1, 2 and 3 was quite similar in species composition, while Station 4 showed a less similar bottom fauna which may be attributed to a slight reduction in water quality. Stations 5, 6 and 7 were similar but had a decidedly different fauna from upstream stations. They shared a very few pollution-tolerant forms. Stations 8 and 9 had many forms in common which indicate moderate pollution at both. The similarity of the bottom fauna at Stations 9 and 3 indicates that water quality at Station 9 was fair and to a degree in a better state than at Station 8.

ZOOPLANKTON

Genera Present

The seven genera observed in samples taken from the Welland River were the cladocerans, Daphnia, Latonopsis, Bosmina and Pleuroxus, the copepods, Cyclops and Diaptomus, and the rotifer, Brachionus.

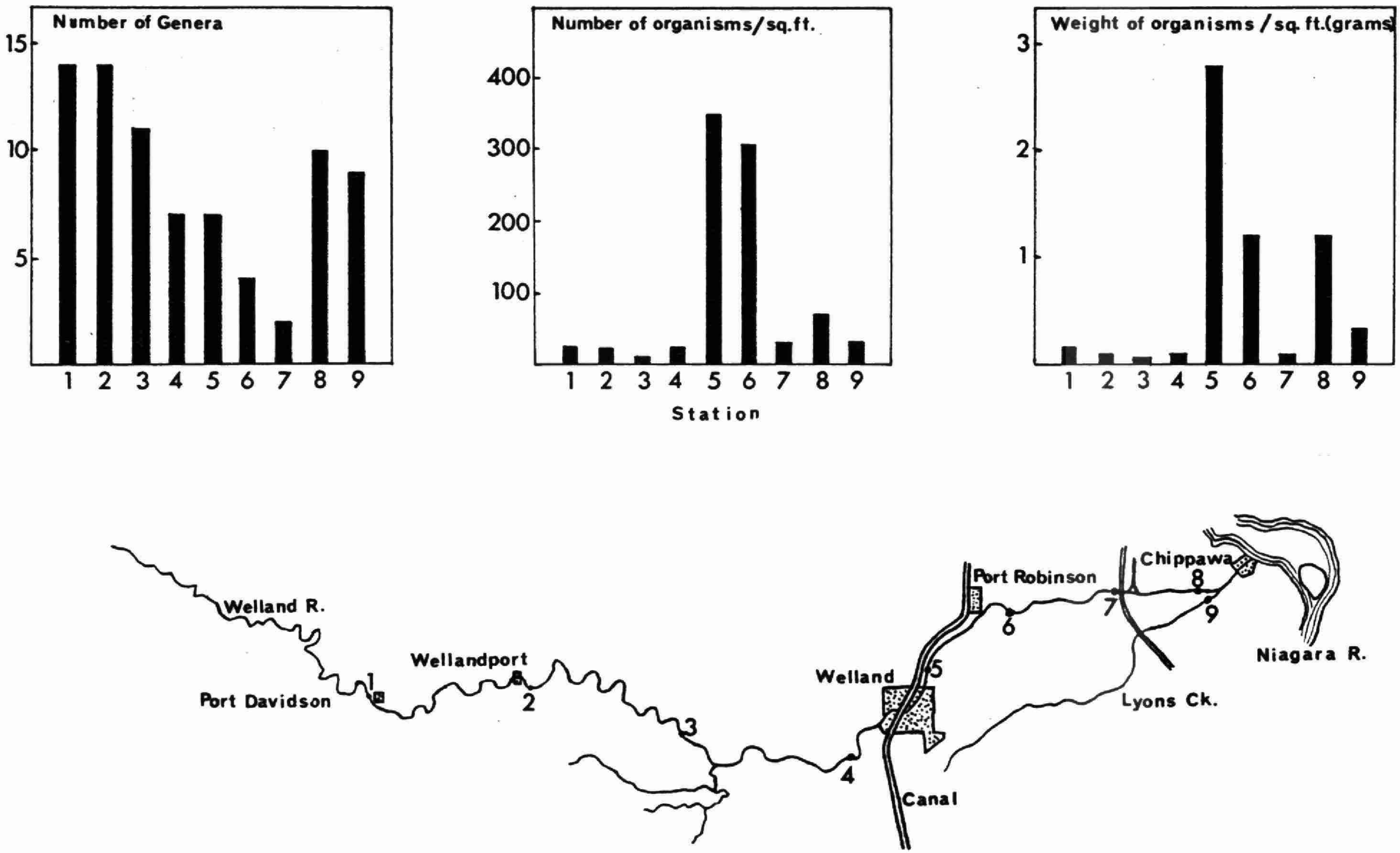

Fig. 4. Number of genera, number and weight of organisms taken per square-foot of bottom at nine stations on the Welland River in June,1964.

Table 5. Degree of similarity in composition of bottom fauna among nine stations on the Welland River as expressed using the coefficient of similarity (explained by example below).

	STATION 1	2	3	4	5	6	7	8	9
1									
2	.71								
3	.72	.80							
4	.48	.48	.55						
5	.19	.19	.22	.29					
6	.33	.33	.40	.55	.55				
7	.25	.25	.31	.44	.44	.67			
8	.41	.50	.48	.35	.47	.43	.33		
9	.43	.52	.60	.50	.38	.46	.36	.63	

$$\text{Coefficient of similarity (Stations 1 and 2)} = \frac{2 \times \text{number forms common to both stations}}{\text{number forms at 1} + \text{number forms at 2}}$$

Magnitude of Populations

The volume of plankton was great at Stations 1, 2 and 3, depressed at Station 4 and very low at all of the downstream stations. With each unit of effort 150 to 260 mls. of plankton were collected at the three upstream stations, 24 mls. were collected just above Welland and no more than 12 mls. were collected with each unit of effort below Welland.

Effect of Pollution on Zooplankton

The depression of the standing crop of plankton at Station 4 to one-tenth of crops upstream may be a result of the much greater population of minnows at that point. Predation by minnows would not explain the very low volumes below Welland, except possibly at Stations 6 and 9. Impaired water quality would appear to be responsible for the low populations of zooplankton, especially at Stations 5, 7 and 8.

A variety of genera of crustaceans was found above Welland (Fig. 5). All but Bosmina were detected at Station 4. At Station 5 cladocerans were very uncommon and Cyclops was much more abundant than Diaptomus. Nauplii of copepods were quite common. Cladocera were more abundant at Station 6, but still were outnumbered about 25.1 by copepods. At Station 7 Brachionus was most abundant, Cyclops was common, but few cladocera and no Diaptomus was observed. Brachionus and a very few Cyclops were collected at Station 8. At Station 9 rotifers predominated while Cyclops, Diaptomus and Pleuroxus were present also. It appears then, that all cladocera were reduced by poor water quality while Cyclops and to a lesser degree Diaptomus persisted. Rotifers were abundant in spite of high ammonia concentrations at Stations 7 and 8, presumably because of the presence of great numbers of algae. The overall effect of impaired water quality was to reduce both the number of forms and number of

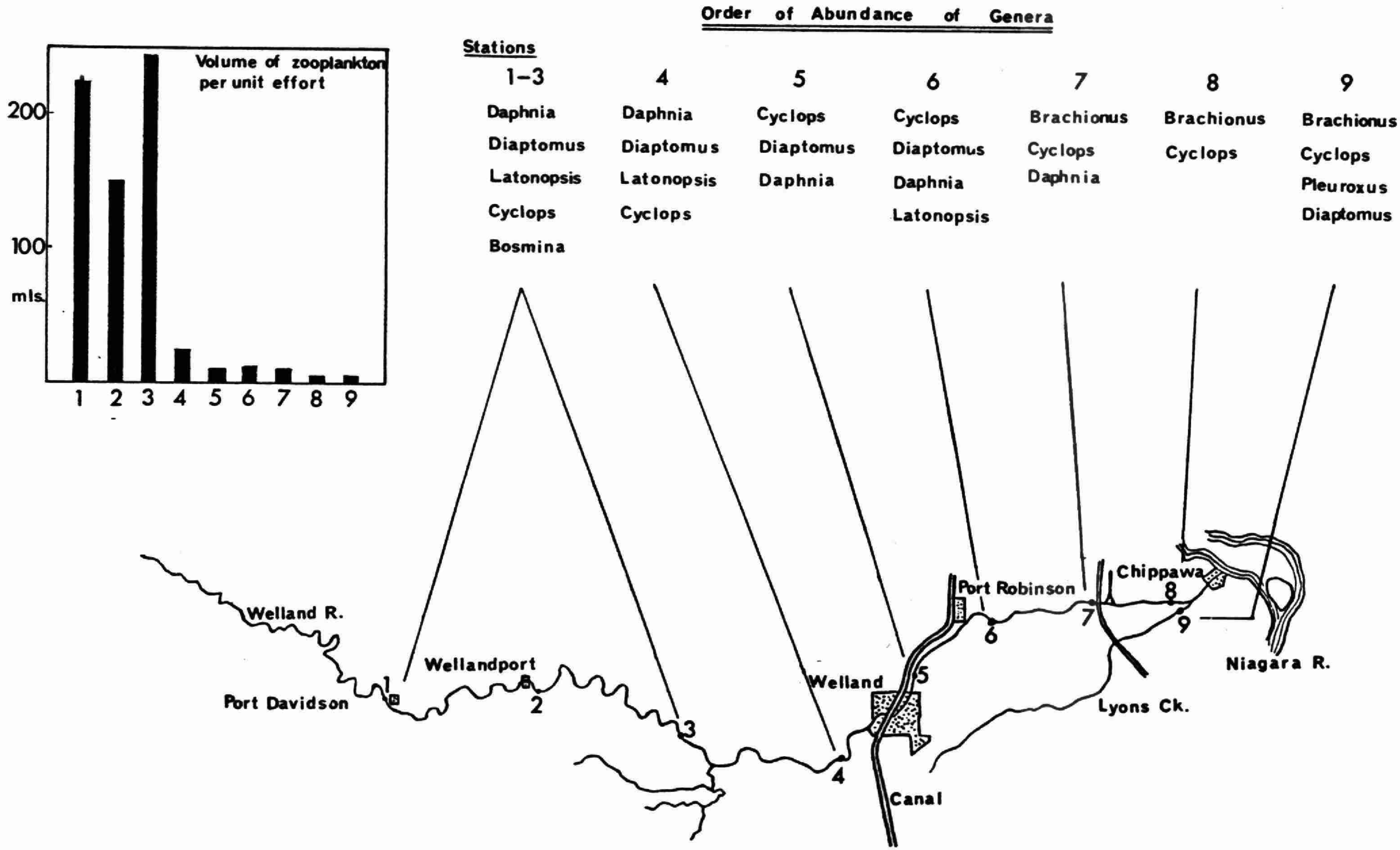

Fig. 5. Volume of zooplankton and its composition taken per standard unit of effort at nine stations on the Welland River, July, 1964.

individuals of zooplankters. Figure 5 illustrates the differences in standing crop and composition of zooplankton populations among the nine stations.

PLANT COMMUNITIES

Rooted Aquatics and Filamentous Algae

The upper Welland River is characterized by an abundance of emergent aquatics, Typha latifolia, Sagittaria Spp., and Glyceria Spp. being most prominent, substantial growth of both Nuphar advena and Nymphaea odorata, but limited development of the submergents, Ceratophyllum demersum, Potamogeton zosteriformis and Potamogeton americanus. At Station 1 submergents were common to a depth of about 3 feet, but at Stations 2, 3 and 4 submergents were very sparse. Emergent and floating aquatics were common throughout, and the filamentous alga, Cladophora, was common at Station 4.

At Station 5 the submergents, Potamogeton pectinatus and Potamogeton Richardsonii, were abundant to a depth of 5 feet, forming a heavily vegetated zone about 12 feet wide along each bank. Filamentous algae, Spirogyra and Ulothrix, were observed growing throughout the pondweeds and beyond them to a depth of about 6 to 8 feet. Hydrodiction was abundant between Stations 5 and 6, while less abundant growths of Spirogyra and Ulothrix were observed at Station 6. Cladophora did not appear to be common below Welland. These growths became much more sparse towards Station 6. The peak in abundance of rooted submergents and filamentous algae occurred at a point about midway between Stations 5 and 6. Waterlilies and submergent aquatics were absent at Station 7, while

streamside vegetation, mainly Typha and Sagittaria was extremely luxuriant. Station 8 was similar to Station 7, while, in contrast, a moderate amount of submergent vegetation was present at Station 9 in association with the algae Hydrodiction and Cladophora.

Phytoplankton

Thirty-one genera of planktonic algae were observed in samples collected by the Stream Sanitation Branch in July. Green algae predominated with 18 genera, while blue-green algae and diatoms were represented by four and six genera respectively.

Populations were low throughout the Welland River except below the Cyanamid plant, where a large number of genera made up a very dense population. A reduction in the number of genera and standing crop of algae was evident below Welland (Table 6). All of the common genera taken below Welland are known for tolerance to pollution. Several genera, possibly intolerant to pollution, were absent below Welland including Schroederia, Closteriopsis and Selanastrum, which were common in samples taken above the city. These three genera of algae are not described as pollution-tolerant forms (Palmer, 1957). At Port Robinson they were collected, along with a greater variety of algae which indicates some improvement at that point.

A total of 24 genera of algae was established for samples taken below the Cyanamid plant. Several forms, not noted for their tolerance, were common. Apparently the levels of ammonia did not impede the development of a varied and abundant population, and, in fact, together with a high level of phosphorus, appeared to have promoted algal growth.

The distribution of algae is shown in table 6. Twenty genera are ranked in order of their apparent tolerance of pollution as described by

Table 6. Occurrence of algae of 31 genera in the Welland River in July, 1964. Tolerant genera are listed in order of their apparent tolerance according to Palmer (1957). Unrated genera are those which are not included in Palmer's list.

Genera	Above Welland (PW 27.0 and 21.1)	Immediately Below Welland	Port Robinson	Montrose
Tolerant Genera				
Oscillatoria	+			+
Euglena	*			+
Navicula	+	+	+	
Chlorella	*	*	*	*
Chlamydomonas	*	*	*	+
Nitzschia				+
Scenedesmus		*	*	+
Synedra		+	+	
Melosira		*	*	+
Anabaena	+			
Ankistrodesmus	+	+		*
Pediastrum	+		+	+
Anacystis	+			
Cyclotella	+			
Microtinium			+	*
Closterium				+
Chlorococcum		+		*
Agmenellum				+
Stephanodiscus	*	+		
Oocystis	+	+	+	*
Unrated Genera				
Schroederia	*		*	*
Closteriopsis	*		+	*
Selenastrum	*		+	
Crucigenia	+	+	+	*
Dictyosphaerium				+
Protococcus			+	+
Coelastrum			+	+
Actinastrum				+
Franceia				+
Quadrigula				+
Ceratium	+			
Number of Genera	17	11	15	24

* most abundant

\+ present

Palmer (1957). The remaining 11 genera are shown in no special order since they were not listed among the 50 most tolerant genera by Palmer. Therefore, most of them may be much less tolerant of pollution than the other 20 genera found in Welland River samples.

SIGNIFICANCE OF BIOLOGICAL RESULTS

The Welland River is the most important natural watercourse in the Niagara Penninsula with, of course, the exception of Great Lake waters. The river above Welland is characterized by low flows and turbid conditions. Nonetheless it attracts several recreational activities including fishing, boating and cottage development. Important highways follow the course of the river eastward to Welland -- the drive is, in fact, a very scenic one.

A number of anglers were observed on the upper Welland during the course of the survey. A brief creel census conducted by personnel of the Niagara Penninsula Conservation Authority indicated fair angling for a river of its type: 17 anglers fished for 24 man-hours and caught 14 fish, a return of 0.6 fish per man-hour. The re-establishment of game fish populations, particularly the pike, following the recorded winter-kill should improve the quality of angling.

Boat-launching facilities are present at three locations, two at O'Reilly's Bridge and one at Beckett's Bridge. The upper river is navigable for outboard craft to Port Davidson. Many boats are owned by riverside property owners. In fact, some cottage development has taken place along the upper river and the owners boat and swim in the river. A private park has been established at one site.

The Niagara Penninsula Conservation Authority has acquired 277 areas along a 3/4-mile stretch of the upper Welland River. Facilities for picnicing,

fishing, boating and hiking are planned. The Township of Pelham operates a 15-acre park above O'Reilly's Bridge. Public ownership of lands along the upper Welland will increase as the Conservation Authority expands its land-acquisition program.

A summary of findings in the biological survey is provided in graphical form (Fig. 6). At present, water quality in the upper river is reasonably good as indicated by the presence of as great a variety of aquatic organisms as could be expected in a naturally slow and turbid river. Because of the nature of the upper Welland River any pollution would increase the frequency and severity of periods of critical oxygen supply. This probably would reduce the production of useful fish-food organisms, for example, zooplankton, mayflies and amphipods, and could increase the frequency of winter-kills of fish. Therefore, under such conditions of flow and stream character, the addition of any significant amount of pollution of any type would be disastrous from a biological point of view.

The lower river, because of its impaired quality, is little used for recreational activities between Welland and the Montrose Bridge (Q.E.W.). A very few private boats were seen. However, a large number of boats is maintained at marinas above Chippawa and below the Chippawa-Queenston Power Canal intake on both the main river and Lyons Creek. Usually this section of the river contains Niagara River water. Consequently, the area of impaired water quality is normally between Welland and the Chippawa-Queenston Power Canal. The two main sources of pollution are the City of Welland and Cyanamid of Canada Limited (Welland Works).

The City of Welland, with a population of 37,000 and considerable industrial development, provides no waste treatment, although plans for such

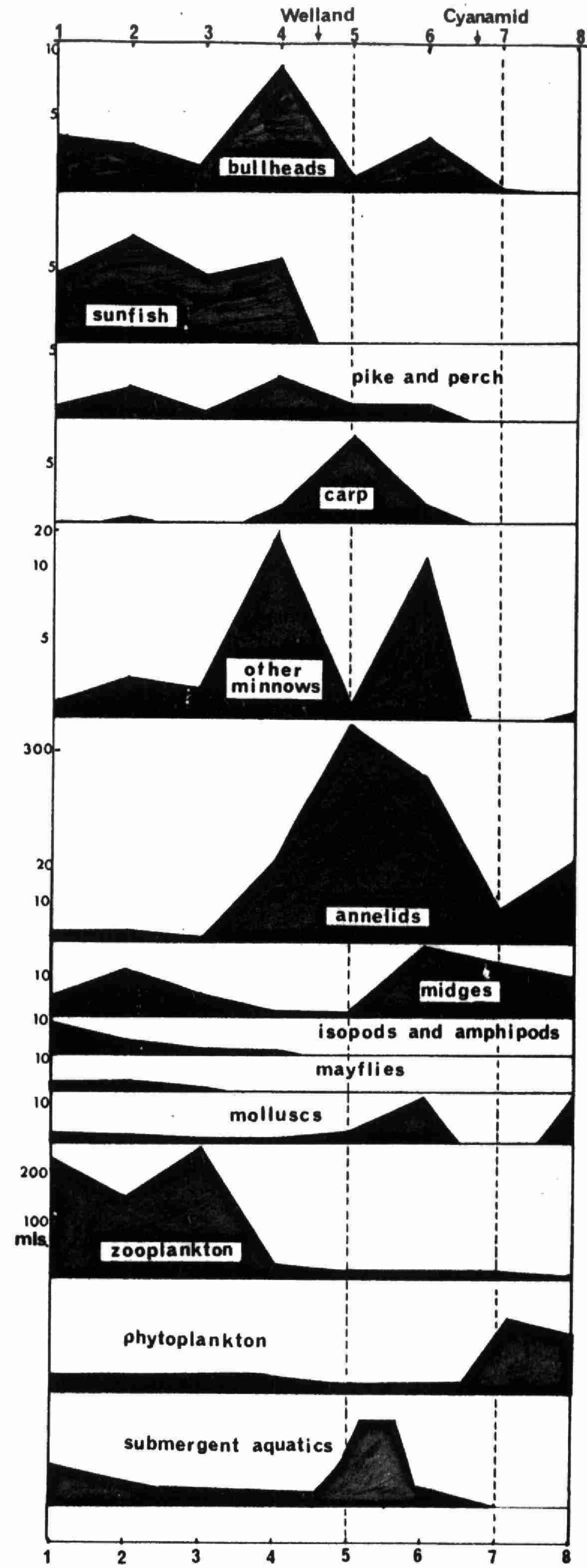

Fig. 6. Relative abundance of several groups of plants and animals taken from the Welland River in June and July, 1964.

have been prepared. A staged program was adopted including the interception of all wastes presently discharged to surface watercourses, the construction of a primary treatment plant (8.0 mgd) to service 75 percent of the city by 1968 and the provision of secondary treatment before 1975.

Some damage to fish and fish-food organisms was evident in results of the biological survey. The numbers of species of fish and genera of bottom fauna organisms were reduced by about one-half with pollution-tolerant forms surviving and producing much greater standing crops. Some recovery was noted at Port Robinson. Probably the greatest damage done to the Welland River is the elimination of aesthetic qualities. The river immediately below Welland is grey and foul, further downstream it is often of an orange colour and murky. The colour change probably proceeds concurrently with the entry and oxidation of iron in steel mill wastes. Between Port Robinson and Cyanamid of Canada aesthetic qualities are slightly improved. Only this lower section is at all amenable to restricted recreational activity such as boating.

Lands between the Welland River and the Welland Canal and a considerable acreage of land west of the Canal and north of the river below Port Robinson are zoned as greenbelt by the Township of Thorold. This area may be one of few which will be suitable for parkland development in the expanding industrial area straddling the Welland Canal in future years. Its use as such by any agency will depend on the condition of the Welland River. The complete implementation of plans for waste disposal from the City of Welland is important. The importance of dilution water from the Welland Canal to the river is obvious since a fish population, although of poor quality and little use, <u>does exist</u> downstream from Welland.

Without dilution water conditions certainly would be intolerable for a fish population of any type. Therefore, the addition of dilution water should be a continuous part of the water conservation program. Considerable improvement in the potential of the river for recreation will be realized with adequate dilution of well-treated wastes. The present biological survey will serve as a basis for assessing future improvements.

The effects of wastes from Cyanamid of Canada Limited on most forms of life are devastating. From a biological viewpoint these effects are of considerably greater import than those wastes from the City of Welland. Improvements should be made concurrently with corrective measures undertaken at Welland. A reduction in ammonia is required so that no more than 2 ppm may be determined at any time in the river proper.

The city of Niagara Falls has zoned as greenbelt (open space) all land between the Chippawa Creek Road and the Welland River. The value of this land for anything more than flood plain control will not be realized until corrective measures are taken by Cyanamid of Canada Limited.

With a thorough program of pollution abatement in the lower Welland River an attractive waterway for boaters will become available. More useful fish populations, augmented probably by fish from the Niagara River, will provide opportunities for anglers. Land which is presently zoned as greenbelt may be developed as parkland as the demand for recreational facilities increases in the years ahead.

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APPENDIX

Table 1. Catch of fish from nine stations on the Welland River, June, 1964.

Table 2. Number of individuals of each genera of bottom fauna in each Ekman-dredge collection - Welland River, June, 1964.

Table 1. Catch of fish from nine stations on the Welland River, June, 1964.

Species	Stations 1	2	3	4	5	6	7	8	9
White sucker								2	1
Carp		2		5	6	4			2
Golden shiner	5	5	1	3		32			
Creek chub									1
Emerald shiner		1	1	3					72
Spottail shiner				16		1		2	197
Bluntnose minnow		7	5	57	1	2			1
Brown bullhead	18	16	7	33	1	11	1		60
Tadpole madtom	3	2	2						1
Mudminnow			1						
Northern pike	3	3			1				
Killifish					1				
Rock bass									2
Pumpkinseed	3	23	12	10					3
White crappie	11	2	2	6					
Black crappie	10	11	4	7					
Yellow perch	1	8	2	11		3		1	2
Johnny darter				1					
Number seine hauls	5	5	4	4	1	3	4	4	4

APPENDIX A

Table 2. Number of individuals of each genera of bottom fauna in each Ekman-dredge collection -- Welland River, June, 1964.

Genus	Station 1						Station 2					
	1	2	3	4	5	6	1	2	3	4	5	6
Oligochaets												
Limnodrilus	3				1	4	3	3	1		1	
Tubifex												
Lumbriculus												
Leeches												
Erpobdella												
Amphipods												
Grammarus			14				6			2		
Isopods												
Asellus	1		16		2		3	1				
Mayflies												
Hexagenia	4	1					1	1	2			
Caenis		2	1									1
Alderflies												
Sialis												
Beetles												
Dubiraphia			1	1		1						
Helophorus												
Flies												
Chaoborus				1	1			1	2			
Palpomyia								4			1	
Procladius			1			1	3	2	6	1		2
Anatopynia												
Chironomus								2	5		1	
Cryptochironomus	1		2			1			1			
Glyptotendipes							1					
Tanytarsus			2									
Polypedilum			4			2		1				
Calopsectra												
Tipula								1				
Mites												
Hydrachna				1								
Molluscs												
Margaritifera					1							
Valvata												
Campelloma												
Sphaerium	3	1			2	2						5
Pisidium												
Total Number	12	3	41	3	7	11	19	16	24	3	3	8
Total Weight(gms.)	.21	.03	.08	.01	.15	.04	.09	.07	.07	.01	.01	.07

Table 2. Continued - Welland - 1964.

Genus	Station 3						Station 4					
	1	2	3	4	5	6	1	2	3	4	5	6
Oligochaets												
<u>Limnodrilus</u>		1			1		3	22	7	17	9	14
<u>Tubifex</u>												
<u>Lumbriculus</u>												
Leeches												
<u>Erpobdella</u>												
Amphipods												
<u>Gammarus</u>	1	1	1		1		2					
Isopods												
<u>Asellus</u>	1				1		1					
Mayflies												
<u>Hexagenia</u>												
<u>Caenis</u>	1											
Alderflies												
<u>Sialis</u>												
Beetles												
<u>Dubiraphia</u>			1									
<u>Helophorus</u>												
Flies												
<u>Chaoborus</u>												
<u>Palpomyia</u>				2								
<u>Procladius</u>		1									1	1
<u>Anatopynia</u>									1			
<u>Chironomus</u>												
<u>Cryptochironomus</u>		1		1								
<u>Glyptotendipes</u>			6		1							
<u>Tanytarsus</u>												
<u>Polypedilum</u>		5			1							
<u>Calopsectra</u>									1			
<u>Tipula</u>												
Mites												
<u>Hydrachna</u>												
Molluscs												
<u>Margaritifera</u>												
<u>Valvata</u>												
<u>Campelloma</u>												
<u>Sphaerium</u>				1	2				2	1		
<u>Pisidium</u>												
Total Number	3	9	8	4	5	2	6	22	11	19	10	14
Total Weight(gms.)	.01	.03	.06	.07	.02	.01	.03	.11	.03	.06	.03	.06

Table 2. Continued - Welland - 1964.

Genus	Station 5			Station 6			Station 7					
	1	2	3	1	2	3	1	2	3	4	5	6
Oligochaets												
Limnodrilus	181	170	192	48	150	290		2	13		7	10
Tubifex	10	8	12									
Lumbriculus												
Leeches												
Gammarus												
Isopods												
Asellus												
Mayflies												
Hexagenia												
Caenis												
Alderfies												
Sialis												
Beetles												
Dubiraphia												
Helophorus				3								
Flies												
Chaoborus												
Palpomyia												
Procladius		2	1	1	1	1	2	48	2	5	6	4
Anatopynia												
Chironomus												
Cryptochironomus												
Glyptotendipes												
Tanytarsus												
Polypedilum												
Calopsectra												
Tipula												
Mites												
Hydrachna												
Molluscs												
Margaritifera												
Valvata		2	1			18						
Campelloma	1											
Sphaerium						1						
Pisidium	2											
Total Number	194	182	206	52	151	310	2	50	15	5	13	14
Total Weight(gms)	1.60	1.35	1.65	.23	.60	1.15	.01	.07	.10	.02	.06	.11

Table 2. Continued - Welland - 1964.

Genus	Station 8						Station 9					
	1	2	3	4	5	6	1	2	3	4	5	6
Oligochaets												
<u>Limnodrilus</u>	10	13	15	13	18	2	3	8	8			
<u>Tubifex</u>	4	1	2	10	1	4		1	3			
<u>Lumbriculus</u>		3	1	1								
Leeches												
<u>Erpobdella</u>		1	1									
Amphipods												
<u>Gammarus</u>												
Isopods												
<u>Asellus</u>												
Mayflies												
<u>Hexagenia</u>												
<u>Caenis</u>												
Alderflies												
<u>Sialis</u>							1					
Beetles												
<u>Dubiraphia</u>												
<u>Helophorus</u>												
Flies												
<u>Chaoborus</u>												
<u>Palpomyia</u>							1	2				
<u>Procladius</u>	6	11	10	7	1	3			1			
<u>Anatopynia</u>												
<u>Chironomus</u>		2	3			1						
<u>Cryptochironomus</u>				1				1				
<u>Glyptotendipes</u>												
<u>Tanytarsus</u>												
<u>Polypedilum</u>			1	2	1		1	1	9			
<u>Calopsectra</u>							1	1				
<u>Tipula</u>												
Mites												
<u>Hydrachna</u>												
Molluscs												
<u>Margaritifera</u>												
<u>Valvata</u>												
<u>Campelloma</u>												
<u>Sphaerium</u>	5	1	2	10	6	8	3	2				
<u>Pisidium</u>	1	1		9	5							
Total Number	26	33	35	53	32	15	10	16	21			
Total Weight(gms)	.41	.39	.75	.84	.92	.60	.47	.07	.04			